UTILIZATION OF GLASS FIBRE TO IMPROVE PROPERTIES OF CONCRETE : A REVIEW

Rajdeep Singh[1], Magandeep Bishnoi[2]
[1]M. Tech Scholar, [2]Asst. Professor
Department of Civil Engineering, Om Institute of Technology & Management
Hisar (Haryana)

Abstract: The poor and unsatisfactory performance of conventional concrete under aggressive environmental conditions has necessitated the researchers and engineers to look for new concrete composites. This new generation technology introduces the discrete glass or synthetic fibres added into the conventional concrete to modify its properties. Fibers are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking. They also help in modifying the permeability of concrete and therefore reduce the flow of water. Various mix proportions of concrete were prepared by the addition of stainless Glass fibres of diameter 14 micron with aspect ratio 857.1. Different properties of concrete e.g. compressive strength , Flexural strength and Split tensile strength at 7 & 28 days have been studied.
Keywords: Stainless Glass Fibres, Compressive Strength, Flexural Strength and Split Tensile Strength.

I. INTRODUCTION

For a long time concrete was considered to be a very durable material requiring a little or no maintenance. The assumption is largely true, except when it is subjected to highly aggressive environments. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments, harmful sub-soil water in coastal areas and in many other hostile conditions where other materials of construction are found to be non-durable. The poor and unsatisfactory performance of conventional concrete under aggressive environmental conditions has necessitated the researchers and engineers to look for new concrete composites. The innovative use of concrete must contemplate explorations of areas , in use of new shapes, materials and technique of construction. Concrete is such a versatile material that such attempts of contemplation are quite possible. In modern age one cannot think of construction work without concrete. Plain concrete has two major deficiencies ; a low tensile strength and allow strain at fracture. The tensile strength of concrete is very low because plain concrete normally contains numerous micro cracks. Hence Fibres are generally utilized in concrete to manage the plastic shrink cracking and drying shrink cracking In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. That"s why the addition of fibre with concrete improved the concrete properties such as workability, brittleness, strength, corrosion resistance and ultimately increased life of the structure. A major advantage of using fibre reinforced concrete besides reducing permeability and increasing fatigue strength is that fibres addition improves the toughness or residual load carrying ability after the first crack. This concrete is known as Glass fibre reinforced concrete (GFRC). Reinforcing capacity and proper functioning of fiber is based on length of fiber, diameter of fiber, the percentage of fiber and condition of mixing, orientation of fibers and aspect ratio. Aspect ratio is ratio of length of fiber to its diameter which plays an important role in the process of reinforcement. GFRC contains only less than 3% of fibres and aspect ratio below 100.

II. GLASS FIBRE

Glass fiber is a material consisting of numerous extremely fine fibers of glass. The introduction of small, closely spaced, randomly oriented fibers transfers an inherently brittle material with low tensile strength and impact resistance into a strong composite with superior crack resistance, improved ductility and distinctive post cracking behaviour prior to failure. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber - reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This structural material product contains little or no air or gas, is more dense, and is a much poorer thermal insulator than is glass wool

III. MANUFACTURING OF GLASS FIBER

Melting

There are two main types of glass fiber manufacture and two main types of glass fiber product. First, fiber is made either from a direct melt process or a marble remelt process. Both start with the raw materials in solid form. The materials are mixed together and melted in a furnace. Then, for the marble process, the molten material is sheared and rolled into marbles which are cooled and packaged. The marbles are taken to the fiber manufacturing facility where they are inserted into a can and remelted. The molten glass is extruded to the bushing to be formed into fiber. In the direct melt process, the molten glass in the furnace goes directly to the bushing for formation.

Formation

The bushing plate is the most important part of the machinery for making the fiber. This is a small metal furnace containing nozzles for the fiber to be formed through. It is almost always made of platinum alloyed with rhodium for durability. Platinum is used because the glass melt has a natural affinity for wetting it. When bushings were first used they were 100% platinum, and the glass wetted the bushing so easily that it ran under the plate after exiting the nozzle and accumulated on the underside. Also, due to its cost and the tendency to wear, the platinum was alloyed with rhodium. In the direct melt process, the bushing serves as a collector for the molten glass. It is heated slightly to keep the glass at the correct temperature for fiber formation. In the marble melt process, the bushing acts more like a furnace as it melts more of the material.

Continuous Filament Process

In the continuous filament process, after the fiber is drawn, a size is applied. This size helps protect the fiber as it is wound onto a bobbin. The particular size applied relates to end-use. While some sizes are processing aids, others make the fiber have an affinity for a certain resin, if the fiber is to be used in a composite.[8] Size is usually added at 0.5–2.0% by weight. Winding then takes place at around 1000 m/min.

Staple Fiber Process

For staple fiber production, there are a number of ways to manufacture the fiber. The glass can be blown or blasted with heat or steam after exiting the formation machine. Usually these fibers are made into some sort of mat. The most common process used is the rotary process. Here, the glass enters a rotating spinner, and due to centrifugal force is thrown out horizontally. The air jets push it down vertically, and binder is applied. Then the mat is vacuumed to a screen and the binder is cured in the oven. Uses for regular glass fiber include mats and fabrics for thermal insulation, electrical insulation, sound insulation, high-strength fabrics or heat- and corrosion-resistant fabrics. It is also used to reinforce various materials, such as tent poles, pole vault poles, arrows, bows and crossbows, translucent roofing panels, automobile bodies, hockey sticks, surfboards, boat hulls, and paper honeycomb. It has been used for medical purposes in casts. Glass fiber is extensively used for making FRP tanks and vessels.

IV. PROPERTIES OF GFRC

- Lighter weight: With GFRC, concrete can be cast in thinner sections and is therefore as much
- as 75% lighter than similar pieces cast with traditional concrete.
- Reinforcement: Since GFRC is reinforced internally, there is no need for other kinds of reinforcement, which can be difficult to place into complex shapes
- Toughness: GFRC doesn't crack easily—it can be cut without chipping.
- Surface finish: Because it is sprayed on, the surface has no bug holes or voids.
- Sustainable: Because it uses less cement than equivalent concrete and also often uses significant quantities of recycled materials (as a pozzolana), GFRC qualifies as sustainable.

V. LITERATURE REVIEW

As we know the properties of concrete gets improved due to the incorporation of Glass fibre. Large no. of papers have being published which tells about the compressive strength, flexural strength and split tensile strength of concrete according to their opinion.

Alejandro Enfedaque Et. Al., [1].

This paper is on the experimental studies made on the analysis of glass fiber reinforced cement (GRC) fracture surfaces. Glass fiber reinforced cement (GRC) is a composite material formed by the combination of cement mortar matrix and chopped glass fibre bonded fibre reinforced polymer sheets. The authors concluded that the strengthened beams exhibit higher load carrying capacity. Ms. K.Ramadevi1, Ms. R. Manju used the Polyethylene Terephthalate (PET) bottles for the reinforcement in concrete with dosage 1%, 2%, 4% and 6% . This paper proved that the replacement of fine aggregates with PET bottles reduces the quantity of river sand and also plastic fibers are proved to be more economical

Asokan.P Et. Al., [2].

Research is carried out on Assessing the recycling potential of glass fiber reinforced plastic waste in concrete and cement composites. Presently, for the glass fiber reinforced plastic (GRP) waste the world wide recycling is very limited on account of its intrinsic thermoset properties,

Bing Chen Et. Al., [3].

This paper presents an experimental study of mechanical properties of normal - strength concrete exposed to high temperatures at an early age. In this study, compressive and splitting tensile strengths of concretes for different curing periods and to high temperatures exposure are obtained.

Guneyisi Erhan Et. Al.,[4].

Experimentally studied, the effects of cement type, curing condition and testing age on the chloride permeability of concrete. The chloride permeability of concrete was held as estimated by rapid chloride permeability test (RCPT). In this research, varied cement types (i.e. plain and four-different blended cements) were used.

Scheffler.C. Et. Al.,[5].

This paper reports on the interphase modification of alkali-resistant glass fibers and carbon fibers for textile reinforced concrete, fiber properties and durability. The sizings and coatings were considered to heal severe surface flaws of brittle alkali resistant glass (ARG) fibers.

Barluenga.G Et. Al.,[6].

developed an experimental program by AR fiber producer, was conducted, to estimate the cracking control ability of alkali resistant (AR) glass fibers in standard concrete and SCC.

Ramakrishna.G Et. Al.,[7].

This paper explain the results of difference in chemical composition and tensile strength of coir, sisal, jute and Hibiscus cannabinus when they are subjected to wetting and drying alternatively and continuous immersion for 60 days in three media (water, saturated lime and sodium hydroxide

Enrico Papa Et. Al., [8].

Shows the Experimental characterization and numerical simulations of a syntactic-foam/glass-fibre composite sandwich : A review on the results of an experimental and numerical investigation performed by the author on the mechanical behaviour of a composite sandwich initially designed for naval engineering applications.

VI. MATERIALS USED

Materials required for making GFRC essentially consist of cement, fine sand, coarse aggregates and Glass fibre. These materials are described below-

CEMENT: Ordinary Portland cement is used in this experimental work as per IS 4031-1988.

FINE AGGREGATES: Locally available river sand passed through 4.75mm IS sieve has been used in the preparation of GFRC. It confirms to IS 383-1970 which comes under Zone.

COARSE AGGREGATES: The Coarse aggregate are obtained from a local quarry has been used. In this experimental work coarse gravel of 20mm and crushed aggregate of 10mm are mixed in 60:40.

GLASS FIBRE:- The introduction of small, closely spaced, randomly oriented fibers transfer an inherently brittle material with low tensile strength and impact resistance into a strong composite with superior crack resistance, improved ductility and distinctive post cracking behavior prior to failure. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber - reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass.

WATER: - Water used for mixing and curing was clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic substances that may be deleterious to concrete. As per IS 456- 2000 Potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly, potable tap water was used for the preparation of all concrete specimens.

VII. METHODLOGY

CONSISTENCY TEST:This is a test to estimate the quantity of mixing water to form a paste of normal consistency defined as that percentage water requirement of the cement paste, the viscosity of which will be such that the Vicat's plunger penetrates up to a point 5 to 7 mm from the bottom of the Vicat's mould.

INITIAL AND FINAL SETTING TIME:-The initial setting time may be defined as the time taken by the paste to stiffen to such an extent that the Vicat's needle is not permitted to move down through the paste to within 5 ± 0.5 mm measured from the bottom of the mould. The final setting time is the time after which the paste becomes so hard that the angular attachment to the needle, under standard weight, fails to leave any mark on the hardened concrete. Initial and final setting times are the rheological properties of cement

SOUNDNESS TEST: It is essential that the cement concrete does not undergo large change in volume after setting. This is ensured by limiting the quantities of free lime and magnesia which slake slowly causing change in volume of cement (known as unsound). Soundness of cement may be tested by LeChatelier method or by autoclave method. For OPC, RHC, LHC and PPC it is limited to 10 mm, whereas for HAC and SSC it should not exceed 5 mm.

COMPRESSIVE STRENGTH:-The compression test shows the compressive strength of hardened concrete. The compression test shows the best possible strength concrete can reach in perfect conditions. The compression test measures concrete strength in the hardened state. Testing should always be done carefully. Wrong test results can be costly.The testing is done in a laboratory off-site. The only work done on-site is to make a concrete cylinder for the compression test. The strength is measured in Megapascals (MPa) and is commonly specified as a characteristic strength of concrete measured at 28 days after mixing. The compressive strength is a measure of the concrete's ability to resist loads which tend to crush it.

Procedure for compression test of concrete:-

Clean the cylinder mould and coat the inside lightly with form oil, then place on a clean, level and firm surface, ie the steel plate. Collect a sample.

Fill 1/2 the volume of the mould with concrete then compact by rodding 25 times. Cylinders may also be compacted by vibrating using a vibrating table.

Fill the cone to overflowing and rod 25 times into the top of the first layer, then top up the mould till overflowing.

Level off the top with the steel float and clean any concrete from around the mould.

Cap, clearly tag the cylinder and put it in a cool dry place to set for at least 24 hours.

After the mould is removed the cylinder is sent to the laboratory where it is cured and crushed to test compressive strength.

SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Procedure of Splitting Tensile Test:

- Take the wet specimen from water after 7 days of curing
- Wipe out water from the surface of specimen
- Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.
- Note the weight and dimension of the specimen.
- Set the compression testing machine for the required range.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate to touch the plywood strip.
- Apply the load continuously without shock at a rate

of approximately 14-21kg/cm2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute)

- Note down the breaking load(P)

FLEXURE STRENGTH TEST

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6 inch (150 x 150-mm) concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading).Flexural Strength of ConcreteFlexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR determined by third-point loading is lower than the MR determined by center-point loading, sometimes by as much as 15%.

The flexural strength was calculated as follows.

Flexural strength (MPa) = (P x L) / (b x d2),

Where, P = Failure load, L = Centre to centre distance between the support = 640 mm, b = width of specimen=150 mm, d = depth of specimen= 150 mm.

VIII. OBJECTIVE

- To find the M30 concrete properties due to addition of glass fibres.
- To study the comparison between the compressive strength of plain concrete and GFRC.
- To study the comparison between the Flexural strength of plain concrete and GFRC.
- To study the comparison between the Split Tensile strength of plain concrete and GFRC.
- To find the economical mix of GFRC.
- To find the workability of GFRC.

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